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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification [6] :
H05K 9/00, H01B 1/14, 1/16, 1/20, 1/22, B22F 7/00

A1

(11) International Publication Number: WO 98/20719

(43) International Publication Date: 14 May 1998 (14.05.98)

(21) International Application Number: PCT/US97/20746

(22) International Filing Date: 7 November 1997 (07.11.97)

(30) Priority Data:
60/030,788 7 November 1996 (07.11.96) US

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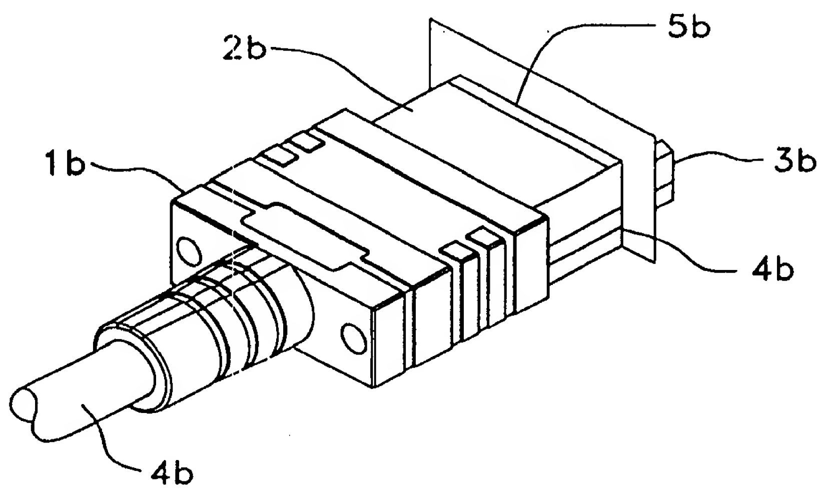
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: MATERIALS FOR RADIO FREQUENCY/ELECTROMAGNETIC INTERFERENCE SHIELDING

(57) Abstract

The present invention provides an RFI and/or EMI shielding composition comprising a polymer, and an effective amount of metal particulates material in a size ranging from about 10 nm to about 100 μm in length incorporated in said polymer. The figure exemplifies a cable connector which contains the shielding composition.



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MATERIALS FOR RADIO FREQUENCY / ELECTROMAGNETIC INTERFERENCE SHIELDING

Related Applications

This application claims the benefit of U.S. Provisional Application No. 60/030,788, filed November 7, 1996.

Field of the Invention

This invention relates to materials useful in electronic devices, and particularly to plastic materials which are effective to provide radio frequency/electromagnetic interference shielding.

Background of the Invention

Plastic materials are routinely employed in the electronics industry in many diverse applications, some examples of which include, without limitation, cables, connectors, peripherals, and wired/wireless (cellular) networks in communication equipment and computers,

navigational equipment, consumer/ industrial medical applications, audio/video products, appliances, lighting, power generation and distribution applications, buildings, and various electrical components in vehicles.

As strong electromagnetic signals from outside sources can adversely effect the performance of usually sensitive electronics equipment, oftentimes plastic materials are used which are effective to shield such equipment from radio frequency/electromagnetic interference ("RFI/EMI"). In some applications, finely divided conductive substances are dispersed in plastic to provide a conductive composite material effective to provide RFI/EMI shielding. Such substances have included carbon, silver and aluminum flakes. As an example, in U.S. Patent No. 4,528,213 to Nelson et al., a composite suitable for RFI/EMI shielding is disclosed which employs finely divided conductive carbon black and graphite dispersed in a thermoplastic resin. This material is disadvantageous, however, due to the low conductivity of carbon powder and the high loading levels required for the desired effective RFI/EMI shielding.

In another example, U.S. Patent No. 4,963,291 to Bercaw, discloses electromagnetic shielding resins which comprise electroconductive particles, such as iron, aluminum, copper, silver and steel in sizes ranging from 0.5 to 50 μm in spherical cross-section, and electrically non-conductive particles, such as mica, quartz, glass, aluminum silicate and alumina in sizes ranging from 0.005 to 2 μm in diameter.

Other examples include U.S. Patent No. 4,695,404 to Kwong, which discloses a polymeric composition comprising a polymeric binder and a silver powder comprising particles and/or flakes having a diameter of from about 0.1 to 44 μm; U.S. Patent No. 4,545,926 to Fouts, comprising conductive polymer compositions comprising a polymeric material in which is dispersed conductive metal particles which have a preferred particle size of about 0.01 to about 200 μm, along with a particulate filler; and U.S. Patent No. 4,407,624 to Ehrreich which provides an organic resin matrix in which is incorporated silver flake-shaped particles 0.1 μm thick or less.

While such compositions may provide the requisite RFI/EMI shielding, they are difficult and expensive to manufacture due to high viscosities encountered upon the combination of polymeric and relatively large sized particulate matter. An important need thus exists for plastic or other compositions which are effective to provide desired RFI/EMI shielding for electronic components, and which can be easily and inexpensively manufactured.

Summary of the Invention

The present invention overcomes the above-identified problems by providing a novel and improved RFI/EMI shielding composition and process for its production which utilizes metallic conductive particulate materials in a size range heretofore not known and/or contemplated in electrical systems

and electrical components, and which are easily dispersed in polymeric materials such as plastic.

Accordingly, in its broadest sense, the present invention provides a composition comprising a polymer and metal particulate material ranging in size from about 10nm to about 100μm in length and preferably from about 1μm to about 100μm in length, wherein said composition has an electrical conductivity effective to provide FRI/EMI shielding.

In another aspect of the invention, there is provided a process for manufacturing such RFI/EMI effective shielding material and various products of manufacture produced therefrom, such as electrical components and the like.

The invention will be more fully understood from the following detailed description with accompanying examples of preferred embodiments.

Brief Description of the Drawings

FIG. 1 graphically illustrates specific electrical resistivity (DC) of a composition of the present invention which comprises silver nano-size powder and silver flakes in an epoxy matrix as a function of silver volume percent content.

FIG. 2 is perspective drawing of a conventional cable connection endpoint assembly.

FIG. 3 is a drawing of a cable connector endpoint assembly manufactured from a composition of the invention.

Detailed Description of Preferred Embodiments

Radio frequency/electromagnetic interference (RFI/EMI) is the impairment of the performance of an electrical system or component and the like by unwanted electromagnetic disturbances. The present inventive compositions comprise a polymeric material and nanometer-size particulate material in which the composition has an electrical conductivity effective to provide shielding against such interference. Noise or interference is often introduced into, for example, circuits by extraneous voltage signals coupled into the circuit from the surroundings. The most common sources of noise comes from the 60 Hz electromagnetic fields (EMI) produced by power mains and from 10 E+3 Hz to 10 E+9 Hz "radio" fields (RFI) produced by many electronic circuits. The voltage signals induced by low frequency EMI fields is called "hum" since it is audible as low frequency tones in amplifiers connected to loud speakers. Other stray voltage pickup may result from electric fields generated by nearby electronic devices and equipment, electric motors, lightning and electrostatic discharges, etc. It is desirable to shield those portions of a circuit where the actual voltage signal is small and consequently where the noise voltages are the most troublesome. The electric fields induce stray voltages capacitively. The magnetic fields induce stray

voltages inductively. Hence, it is only necessary to surround the most vulnerable portions of a circuit or cable connector assembly with a grounded conducting shield in order to reduce stray voltage pickup. Such shielding is also effective in reducing so-called "cross-talk" between two different stages or portions of the same component such as a circuit or cable connector assembly.

The RFI/EMI shielding ability of a material can be determined if the material is "metallic-like" in electrical behavior, by the material's "skin depth" which is defined as the thickness of "metallic-like" material required to reduce the noise, stray or interference voltage (electric field) to 1/e(1/e=0.369 where e = exponential constant = 2.710) of the value at the surface of the material. For electromagnetic waves with frequency (f) less than 10E+14 Hz (below the optical range of the spectrum), the "skin depth" of "metallic-like" materials is given by the equation:

$$d = 1/\sqrt{\pi\sigma\mu f}$$

where f = electromagnetic wave frequency

σ = electrical conductivity of the "metallic-like" material

μ = magnetic permeability of free space

π = 3.1416 . . .

d = skin depth of the "metallic-like" material

Silver, for example, has an electrical conductivity of 3 x 10 E+5 inverse ohm-cm at a common microwave frequency (10E+10 Hz). The skin depth of silver in this case is 9.2 x 10E-5 cm. Thus, at microwave frequencies, the skin depth in silver is very small, and hence the difference in performance between a pure silver component and a silver-plated component made with a base of copper or brass would be expected to be negligible, which is the case. Silver plating is therefore used to reduce the material cost of high-quality waveguide components for microwave ovens and waveguide components. At 60 Hz low frequency, the skin depth of silver is about 0.836 cm. In copper, the skin depth is 0.850 cm, at 60 Hz low frequency, but the skin depth is 0.71 x 10D-3 cm at the radio frequency of 10E+8 Hz.

Thus, from knowledge of skin depth versus electromagnetic frequencies, the magnitude of skin depths of "metallic-like" material effective to reduce stray interference voltages to an acceptable or otherwise desirable level can be determined. For example, Table I provides the number of skin depths (N) effective to produce a given stray or interference voltage reduction in number of dB down (dB is log base 10). As is known, electronic circuits, cable connectors and assemblies have application specific testing methods/requirements to certify them as adequately RFI/EMI shielded.

TABLE I

N Skin Depths of Material	Number of dB Down Stray Voltage (Log 10)
1	- 0.43
5	- 2.17
10	- 4.32
25	- 10.83
50	- 21.65
100	- 43.30

In the present invention, it has been surprisingly and unexpectedly found that the addition of metallic particles ranging from about 10nm to about 100μm in length and preferably from about 1μm to about 100μm in length to polymeric materials useful for encapsulating or creating structural components produces a composite material of greatly increased electrical conductivity at volume concentrations much less, for example, at least 5 to 20 volume percent less, than that of RFI/EMI materials manufactured with conventional size conductive particles or flakes, respectively.

"Nanoparticles" as used herein can take the form of single entities, for example, of from 10nm to 100nm in diameter, or may exist as "fused strings" of single entities, ranging, for example, from up to 100μm or larger in length. Hence, the term "length" is preferred for use in describing nanoparticles useful in the present invention. Further, in the present inventive compositions the electrical

conductivity-enhancing volume concentrations are effectively low such that thermal conductivity and dynamic viscosity/rheology of polymeric materials are negligibly affected, while electrical conductivity is increased by several orders of magnitude, all of which provides a great advantage over conventional materials in terms of ease of manufacturing and manufacturing costs.

As shown in FIG. 1, in an example of a composition of the present invention, the addition of metallic particulate material (about 5μm to about 10μm in length) to insulating polymer (epoxy) in a preferred volume percent (from about 2 volume percent to about 15 volume percent, as discussed below) greatly increases the electrical conductivity of the polymer at volume concentrations of at least one-fourth that of conventional size micropowders and flakes, or less than five volume percent versus more than twenty volume percent.

Without intending to limit this invention to theory, it is believed that such an increase in electrical conductivity at low volume concentrations is at least due in part to the formation of metal particle-to metal particle contacts forming networks of electron mobile "shunts" for nanoparticles ranging up to about 10μm in length dispersed in insulating polymers. However, it is further believed that electrical conductivity of nanoparticles observed in the inventive insulating polymeric compositions is not due solely to such electron mobile shunts. It is also thought that the individual nanoparticles, which are roughly the size of

polymer molecules and which are very porous, also operate by inducing electron tunneling through the polymer molecules due to the molecular intimacy of the of the nanoparticle-polymer composite material. Such may explain the gap which exists between the lowest resistivity of the dispersed nanoparticles of silver and the resistivity of pure silver in FIG. 1.

Further, in accordance with this invention, volume concentrations of the electrical conductivity-enhancing nanoparticles are maintained such that the thermal conductivity and dynamic viscosity/rheology of the insulating polymer are negligibly affected while electrical conductivity is increased, preferably by several orders of magnitude. Nanoparticle loading in the compositions of this invention preferably range from about 0.10% volume to about 50% volume or greater, depending upon the end use contemplated, are more preferably within the range of from about 2 to about 15 volume percent.

Polymeric materials useful in this invention include any material useful in the electronics industry, including, without limitation, thermoplastics (crystalline or non-crystalline, cross-linked or non-cross-linked), thermosetting resins, elastomers or blends or composites thereof.

Illustrative examples of useful thermoplastic polymers include, without limitation, polyolefins, such as polyethylene or polypropylene, copolymers (including terpolymers, etc.) of olefins such as ethylene and propylene, with each other and with other monomers such as vinyl esters,

acids or esters of α, β-unsaturated organic acids or mixtures thereof, halogenated vinyl or vinylidene polymers such as polyvinyl chloride, polyvinylidene chloride, polyvinyl fluoride, polyvinylidene fluoride and copolymers of these monomers with each other or with other unsaturated monomers, polyesters, such as poly(hexamethylene adipate or sebacate), poly(ethylene terephthalate) and poly(tetramethylene terephthalate), polyamides such as Nylon-6, Nylon-6,6, Nylon-6,10, Versamids, polystyrene, polyacrylonitrile, thermoplastic silicone resins, thermoplastic polyethers, thermoplastic modified cellulose, polysulphones and the like.

Examples of some useful elastomeric resins include, without limitation, rubbers, elastomeric gums and thermoplastic elastomers. The term "elastomeric gum", refers to polymers which are noncrystalline and which exhibit after cross-linking rubbery or elastomeric characteristics. The term "thermoplastic elastomer" refers to materials which exhibit, in various temperature ranges, at least some elastomer properties. Such materials generally contain thermoplastic and elastomeric moieties. For purposes of this invention, the elastomer resin can be cross-linked or non cross-linked when used in the inventive compositions.

Illustrative examples of some suitable elastomeric gums for use in this invention include, without limitation, polyisoprene (both natural and synthetic), ethylene-propylene random copolymers, poly(isobutylene), styrene-butadiene random copolymer rubbers, styrene-acrylonitrile-butadiene terpolymer

rubbers with and without added copolymerized amounts of α, β-unsaturated carboxylic acids, polyacrylate rubbers, polyurethane gums, random copolymers of vinylidene fluoride and, for example, hexafluoropropylene, polychloroprene, chlorinated polyethylene, chlorosulphonated polyethylene, polyethers, plasticized poly(vinyl chloride), substantially non-crystalline random co- or ter-polymers of ethylene with vinyl esters or acids and esters of α, β-unsaturated acids, silicone gums and base polymers, for example, poly(dimethyl siloxane), poly(methylphenyl siloxane) and poly(dimethyl vinyl siloxanes).

Some illustrative examples of thermoplastic elastomers suitable for use in the invention include, without limitation, graft and block copolymers, such as random copolymers of ethylene and propylene grafted with polyethylene or polypropylene side chains, and block copolymers of α-olefins such as polyethylene or polypropylene with ethylene/propylene or ethylene/propylene/diene rubbers, polystyrene with polybutadiene, polystyrene with polyisoprene, polystyrene with ethylene-propylene rubber, poly(vinylcyclohexane) with ethylene-propylene rubber, poly(α-methylstyrene) with polysiloxanes, polycarbonates with polysiloxanes, poly(tetramethylene terephthalate) with poly(tetramethylene oxide) and thermoplastic polyurethane rubbers.

Examples of some thermosetting resins useful herein include, without limitation, epoxy resins, such as resins made

from epichlorohydrin and bisphenol A or epichlorohydrin and aliphatic polyols, such as glycerol, and which can be conventionally cured using amine or amide curing agents. Other examples include phenolic resins obtained by condensing a phenol with an aldehyde, e.g., phenol-formaldehyde resin.

Other additives can also be present in the composition, including for example fillers, pigments, antioxidants, fire retardants, cross-linking agents, adjuvants and the like.

Conductive nanoparticles useful herein can be of virtually any metal effective to increase conductivity of a polymeric material in which it is incorporated, including without limitation, silver, copper, gold, iron, platinum, palladium, tantalum, nickel, tungsten, molybdenum, aluminum, zinc, cobalt, chromium, lead, titanium and tin. Conductive particles of an alloy, such as silver/copper, nichrome or brass, may also be employed.

As found in the present invention, the employ of conductive particle sizes much above about 100μm in length will diminish provision of the aforementioned advantages of the invention of low volume loading coupled with highly increased electrical conductivity with a concomitant negligible change in polymeric thermal conductivity and dynamic viscosity/rheology.

The nanoparticles are preferably spherically shaped, but may also include any other shape such as flakes, rods and the like, and may be obtained from any commercial source, such

as for example, Fraunhofer Institute, Bremen, Germany and the Vacuum Metallurgical Company in Japan.

The composition of the present invention can be prepared by any conventional technique and can be employed, for example, as encapsulating and/or structural polymers for such components as electronic circuits, cables and connector assemblies. For example, the inventive compositions can be prepared by melt blending the polymeric material and nano-particles and other additives if desired in a conventional two or three roll mill, or in a Brabender or Banbury mixer, or by using mechanical stirring depending whether the polymer(s) employed is in liquid form at room temperature. High intensity ultrasonic mixers or high shear stirrers may also be used.

In preparing the metal filled conductive compositions of this invention, conductive and particulate filler are incorporated into thermosetting resins prior to cure. Preferably, thermosetting resins which are liquid at room temperature are employed which facilitate easy mixing with conductive particles. Conductive compositions of thermosetting resins which are solids at room temperature can be easily prepared using conventional solution techniques.

For best results and performance of the inventive compositions, it is preferred that the nanoparticles are homogeneously dispersed throughout the polymeric material employed. It is further preferred that nanoparticles be dispersed throughout the polymer matrix to eliminate any

residual open and closed pore volume within the dispersed metal nanoparticles, to minimize the resistivity gap such as illustrated in FIG. 1.

As set out above, the compositions of the present invention are useful in providing RFI/EMI shielding in a variety of electronic components, such as, for example, circuits, devices, cable connectors, end-point assemblies and the like. The illustrations in FIGS. 2 and 3 show respective cable end-point assembly housings of a design manufactured in a conventional manner and an assembly housing manufactured from the presently inventive composition, respectively.

In FIG. 2, in a conventionally obtained assembly for RFI/EMI shielding, the assembly includes PVC housing 2a with copper foil wrapped around terminal **2b** containing several individually terminated copper wires encapsulated by a polymer adhesive, such as nylon 2c. The copper foil is anchored mechanically and electrically to ground via solder **2d** at necessary locations.

FIG. 3 illustrates a cable end-point assembly utilizing the presently inventive composition which includes housing 3a made of, for example, PVC. A second layer, for example, Nylon 3b, contains nanoparticles, such as, for example, silver, are preferably incorporated into the polymeric material to completely surround the original polyamide encapsulant thereby providing RFI/EMI shielding to

he entire termination structure. The inventive RFI/EMI shielding polymeric layer 3b can be electrically grounded at necessary locations.

CLAIMS

What is claimed is:

1. An RFI and/or EMI shielding composition comprising:

(i) a polymer, and

(ii) an effective amount of metal particulate material particulate in a size ranging from about 10nm to about 100μm in length incorporated in said polymer to provide RFI and/or EMI shielding.

2. The composition of claim 1 which has electrical conductivity greater than or equal to 1 inverse ohm-cm.

3. The composition of claim 1 wherein said polymer is selected from the group consisting of thermoplastics, cross-linked or non-cross-linked, crystalline or non-crystalline; thermosetting resins, elastomers, elastomeric gums, thermoplastic elastomers and blends and composites thereof.

4. The composition of claim 1 having electrical conductivity greater than or equal to 10 inverse ohm-cm.

5. The composition of claim 3 wherein said polymer is a crystalline polymer or a partially crystalline polymer.

6. The composition of claim 1 having electrical conductivity greater than or equal to 100 inverse ohm-cm.

7. The composition of claim 1 wherein said polymer is selected from the group consisting of polyhalo-olefins, polyamides, polyolefins, polystyrenes, polyvinyls, poly-acrylates, polymethacrylates, polyesters, polydienes, polyoxides, polyamides and polysulfides and their blends, co-polymers and substituted derivatives thereof.

8. The composition of claim 1 wherein said metal particulate material is selected from the group consisting of silver, copper, silver/copper alloys, gold, platinum, palladium, aluminum, tantalum, tin, iron, chromium and alloys of said metal materials.

9. The composition of claim 1 wherein the said effective amount of said metal particulate material is present in an amount of about 0.10 volume percent to about 50 volume percent.

10. An RFI and/or EMI shielding article of manufacture comprising:

(i) a polymer, and

(ii) an effective amount of metal particulate material in a size ranging from about 10nm to about 100μm in length incorporated in said polymer to provide RFI and/or EMI shielding to said article of manufacture.

11. The article of manufacture of claim 10 having an electrical conductivity greater than or equal to 1 inverse ohm-cm.

12. The article of manufacture of claim 10 wherein said polymer is selected from the group consisting of thermoplastics, cross-linked or non-cross-linked, crystalline or non-crystalline; thermosetting resins, elastomers, elastomeric gums, thermoplastic elastomers and blends and composite thereof.

13. The article of manufacture of claim 10 having electrical conductivity greater than or equal to 10 inverse ohm-cm.

14. The article of manufacture of claim 10 wherein said polymer is a crystalline polymer or a partially crystalline polymer.

15. The article of manufacture of claim 10 having electrical conductivity greater than or equal to 100 inverse ohm-cm.

16. The article of manufacture of claim 10 wherein said polymer is selected from the group consisting of polyhalo-olefins, polyamides, polyolefins, polystyrenes, polyvinyls, polyacrylates, polymethacrylates, polyesters, polydienes, polyoxides, polyimids and polysulfides and their blends, co-polymers and substituted derivatives thereof.

17. The article of manufacture of claim 10 wherein said metal particulate material is selected from the group consisting of silver, copper, silver/copper alloys, gold, platinum, palladium, aluminum, tantalum, tin, iron, chromium and alloys of said metal materials.

18. The article of manufacture of claim 10 wherein the said effective amount of said metal particulate material has a concentration of about 3 volume percent to about 35 volume percent.

19. An RFI and/or EMI shielding electronic system comprising combinations and permutations of electronic components, enclosures and devices comprising:

(i) a polymer, and

(ii) an effective amount of metal particulate material in a size ranging from about 10nm to about 100μm in length incorporated in said polymer to provide RFI and/or EMI shielding to said electronic system.

20. The electronic system of claim 19 having electrical conductivity greater than or equal to 1 inverse ohm-cm.

21. The electronic system of claim 19 wherein said polymer is a thermoplastic polymer or a partially thermoplastic polymer.

22. The electronic system of claim 19 having electrical conductivity greater than or equal to 10 inverse ohm-cm.

23. The electronic system of claim 19 wherein said polymer is a crystalline polymer or a partially crystalline polymer.

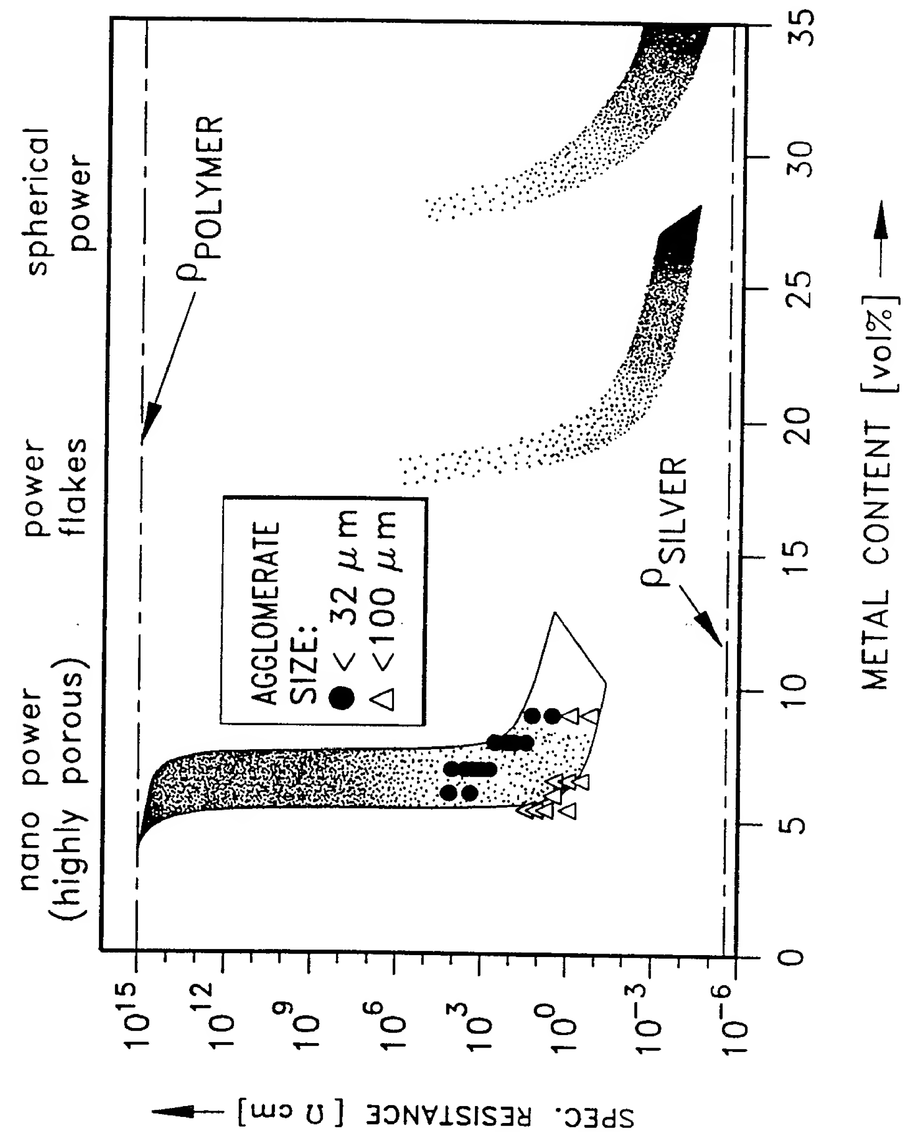
24. The electronic system of claim 19 having electrical conductivity greater than or equal t0 100 inverse ohm-cm.

25. The electronic system of claim 19 wherein said polymer is selected from the group consisting of polyhalo-olefins, polyamides, polyolefins, polystyrenes, polyvinyls, polyacrylates, polymethacrylates, polyesters, polydienes, polyoxides, polyimids and polysulfides and their blends, co-polymers and substituted derivatives thereof.

26. The electronic system of claim 13 wherein said metal particulate material is selected from the group consisting of silver, copper, silver/copper alloys, gold, platinum, palladium, aluminum, tantalum, tin, iron, chromium and alloys of said metal materials.

27. The electronic system of claim 19 wherein said metal particulate material is present in an effective amount of about 3 volume percent to about 35 volume percent.

28. A composition of matter comprising a dispersion of metal particulate material having a diameter ranging from about 10nm to about 100μm in length in a matrix material selected from the group comprising crystalline polymers, amorphous polymers, metals and dielectrics, said metal particulate material being intimately associated with the monomeric units of said polymers or intimately associated with the grains of said metal particulate material, or intimately associated with the crystallites of said dielectrics, and wherein said composition is effective to provide electrical conductivity effective for RFI/and or EMI shielding.



nano power
(highly porous)
power
flakes
spherical
power
$\rho_{POLYMER}$
ρ_{SILVER}
AGGLOMERATE
SIZE:
● < 32 μm
△ <100 μm
METAL CONTENT [vol%]
SPEC. RESISTANCE [Ω cm]
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10^{12}
10^{9}
10^{6}
10^{3}
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25
30
35

FIG. 1

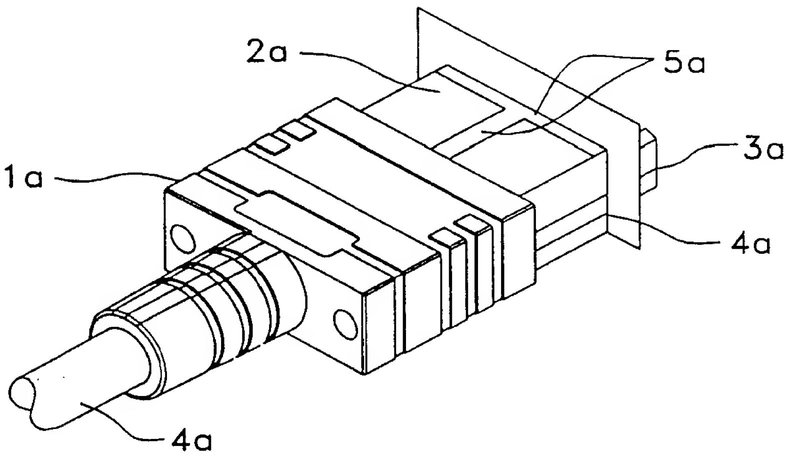

FIG. 2

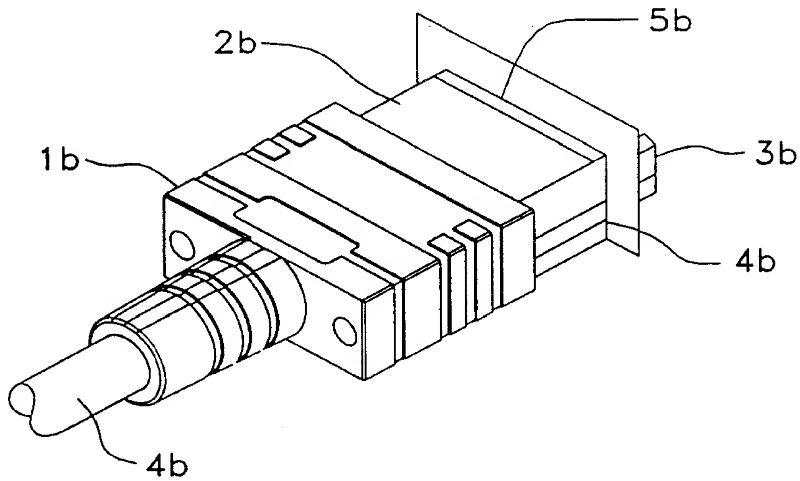

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/20746

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :H05K 9/00; H01B 1/14, 1/16, 1/20, 1/22; B22F 7/00
US CL :Please See Extra Sheet.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 361/818; 523/137; 524/439, 440, 441; 428/546, 548; 252/512, 513, 514

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 4,695,404 A (KWONG) 22 September 1987, col. 2, lines 27-68 and examples 1-6.	1-8, 10-17, 19-26, 28 ----------- 9, 18, 27
X --- Y	US 4,963,291 A (BERCAW) 16 October 1990, col. 1, line 47-col. col. 4, line 35.	1-8, 10-17, 19-26, 28 ----------- 9, 18, 27
X --- Y	US 5,075,038 A (COLE et al) 24 December 1991, col. 2, lines 54-67.	1-4, 6, 8-9, 28 ----------- 10-13, 15, 17-20, 22, 24, 26-27

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
12 FEBRUARY 1998

Date of mailing of the international search report
06 MAR 1998

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/20746

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 5,229,037 A (NAKANO et al) 20 July 1993, col. 2, lines 33-55, col. 6, lines 45-50 and examples 1-3.	1-4, 6, 8, 10-13, 15, 17, 19-20, 22, 24, 26, 28 ----------- 9, 18, 27
X --- Y	US 4,830,779 A (MAENO et al) 16 May 1989, col. 2, line 1-col. 3, line 29.	1-8, 10-17, 19-26, 28 ----------- 9, 18, 27
X	US 4,783,279 A (PETERMANN et al) 8 November 1988, col. 3, line 5-col. 4, line 21.	1-28

A. CLASSIFICATION OF SUBJECT MATTER:
US CL :

361/818; 523/137; 524/439, 440, 441; 428/546, 548; 252/512, 513, 514

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I, claims 1-27, drawn to an RFI and/or EMI shielding composition of an effective amount of metallic particles and a polymer matrix, a shielding article produced from the composition and a RFI and/or EMI shielding electronic system comprising the shielding composition.

Group II, claim 28, drawn to a composition of metallic particles and a matrix selected from metals, dielectrics, crystalline polymers and amorphous polymers, where the amount of metallic particles is the effective amount to provide RFI and/or EMI shielding.

The inventions listed as Groups I and II do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The composition of claim 28, Group II, is not limited to the composition of claims 1-27, which is the inventive concept. Claim 28 teaches composition not taught in claims 1-27.